Reprinted from "Bulletin of Marine Science" Volume 46, 1990, pp. 345-357, Chester and Thayer: Distribution of spotted seatrout (Cynoscion nebulosus) and gray snapper (Lutjanus griseus) juveniles in seagrass habitats of western Florida Bay. With permission from Rosenstiel School of Marine and Atmospheric Science of the University of Miami.

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DISTRIBUTION OF SPOTTED SEATROUT (*CYNOSCION NEBULOSUS*) AND GRAY SNAPPER (*LUTJANUS GRISEUS*) JUVENILES IN SEAGRASS HABITATS OF WESTERN FLORIDA BAY

Alexander J. Chester and Gordon W. Thayer

ABSTRACT

The distribution, abundance and biomass of juvenile spotted seatrout (*Cynoscion nebulosus*) and gray snapper (*Lutjanus griseus*) were evaluated along with information on seagrasses, sediments, water temperature and salinity in basin and channel habitats of western and central Florida Bay during 1984-1985. Spotted seatrout juveniles were most prevalent in basin habitats in the western portion of the Bay, near the Gulf of Mexico, and were collected during every month sampled except May (1984); smallest individuals were collected during May (1985), June (1984, 1985), and July (1984). The habitats in which spotted seatrout occurred had deeper, more organic sediments with greater density and biomass of the seagrass, *Syringodium filiforme,* than did non-seatrout areas (ANOVA, $P < 0.05$). Gray snapper juveniles were most prominent in channels of the southeastern part of the Bay but also occurred in basins located to the northwest. The presence or absence of gray snapper was related to the distribution of seagrass biomass, particularly that of *Thalassia testudinum* in the basins and *Syringodium* in the channels. These data suggest that seagrass meadows are critical habitats for spotted seatrout and gray snapper in Florida Bay.

Florida Bay is a large, relatively shallow, lagoonal estuary lying in the southern portion of Everglades National Park (Fig. 1) (Schomer and Drew, 1982). The Bay consists of a network of mangrove islands and carbonate mudbanks that separate the area into shallow basins. Like many other estuaries of southern Florida, open water basin and carbonate mudbank areas of Florida Bay are characterized by highly productive seagrass habitats dominated by turtlegrass (*Thalassia testudinum*), Cuban shoalgrass (*Halodule wrightii*), and manatee grass (*Syringodium filiforme*) (Zieman, 1982; Zieman et al., 1989; Thayer and Chester, 1989).

Of the four fish species most avidly targeted by sportsfishermen in Everglades National Park (red drum [*Sciaenops ocellatus*], gray snapper [*Lutjanus griseus*], snook [*Centropomus undecimalis*], spotted seatrout [*Cynoscion nebulosus*]; Tilmant et al., in press), the juveniles of gray snapper and spotted seatrout are most linked distributionally to seagrass meadows in Florida Bay (Thayer et al., 1987b; Rutherford et al., 1989, and references cited therein). Spotted seatrout adults are generally nonmigratory, estuarine fish inhabiting shallow, seagrass-rich environments. Johnson and Seaman (1986), summarizing the literature, concluded that spotted seatrout may spawn in non-tidal estuarine areas, near tidal inlets, outside estuaries, and in deeper channels adjacent to seagrass beds. Based on the occurrence of early stage larvae, Powell et al. (1989) reported major spawning activity in the relatively saline waters of western Florida Bay, principally from May to September. Gray snapper are reported to occupy a variety of habitats. Juveniles generally are associated with nearshore grass beds and mangrove edges; adults tend toward deeper channels and offshore reefs (Starck and Schroeder, 1971). Mature gray snapper and early stage larvae are rare in Florida Bay, and spawning is believed to occur offshore (Powell et al., 1989; Rutherford et al., 1989).

In the present paper we utilize data collected as part of a broader study of juvenile fish community structure and distribution within basins and channels of the western half of Florida Bay (Thayer and Chester, 1989). Our goal is to describe the spatial occurrence of spotted seatrout and gray snapper juveniles within this region particularly as it relates to various environmental factors, including the sedimentary character of the bottom and seagrass density, biomass, and species composition.

Materials and Methods

Information on the abundance and biomass of juvenile spotted seatrout and gray snapper along with supporting data on environmental parameters was gathered during nine surveys (May, June, July, September, November—1984; January, March, May, June—1985) of the open water habitats of western and central Florida Bay. Sampling proceeded according to a stratified random sampling plan in which six stations each from four strata were randomly selected during each survey. Open water areas of the Bay were divided east-to-west into three approximately equal-area strata representing basin habitats and one stratum comprising channels between carbonate mudbanks and between islands (Fig. 1). Basin strata were defined on the basis of seagrass distribution, with overall biomass increasing from east to west.

Samples of the fish and invertebrate communities at each station were obtained by towing first a bottom (otter) trawl followed by a surface trawl between two 5-m-long boats. Towing speed was 2.0 ± 0.2 m/sec and trawls were pulled for approximately 2 minutes each. The distance of each tow was estimated by marking the starting and ending point with floating markers and using an optical range finder. After each trawl, fish were placed in labelled sample bags, preserved in 10% formalin, and returned to the laboratory for identification, enumeration, and wet weight determination. Surface and bottom temperature and salinity were measured at the midpoint of each trawl line (YSI model 33 S-C-T meter), and a diver obtained triplicate 100 cm^2 vegetation samples and a sediment sample at the beginning, middle, and endpoint of each trawl line. Sediment thickness, if <2 m, was measured by inserting a marked pole to the bedrock, and water depth was recorded. Sediments were analyzed for organic matter and silt-clay content. Shoot numbers and biomass (dry weight) of the three major seagrass species, *Thalassia testudinum, Syringodium filiforme,* and *Halodule wrightii,* were measured and averaged for each station. Details of the sampling plan and methodology are found in Thayer et al. (1987b) and Thayer and Chester (1989).

Initial analyses of spatial trends and interactions among environmental, seagrass, and juvenile fish parameters were accomplished with univariate ANOVA and bivariate correlation techniques. Discriminant function analysis was used to further characterize those open water habitats likely to support populations of spotted seatrout and gray snapper in Florida Bay. Two stepwise analyses were conducted for each species, one each for basin and channel habitats. Within each habitat, stations were divided empirically into those with and those without the target species. Following an overall test of significance (MANOVA, $P < 0.05$), utilizing environmental and seagrass variables, canonical discriminant functions were derived. The relative importance of discriminating variables was judged by the magnitude of the absolute value of standardized coefficients and the correlation between each variable and the function. A "jackknife" classification analysis (Snapinn and Knoke, 1984) was then conducted, assigning each station equal prior probabilities, to assess the utility of the discriminant function.

Results and Discussion

Environmental Description.—The distribution of environmental parameters within Florida Bay during the study has been described by Thayer et al. (1987b) and Thayer and Chester (1989). Three environmental subregions, exclusive of channels, were discerned. These resembled the provinces proposed by Turney and Perkins (cited by Schomer and Drew, 1982) based on molluscan distribution and by Zieman et al. (1989) based on benthic vegetation.

The Gulf Province encompasses the western part of Florida Bay (Stratum III, Fig. 1). Hydrographic conditions are influenced by the Gulf of Mexico, which communicates with the shallow basins of this region via channels through the bordering mudbanks (Schomer and Drew, 1982; Sogard et al., 1989). This area has relatively deep and organically rich sediments, shallow depths, and a diverse seagrass community composed of *Thalassia, Halodule,* and *Syringodium.* Stations

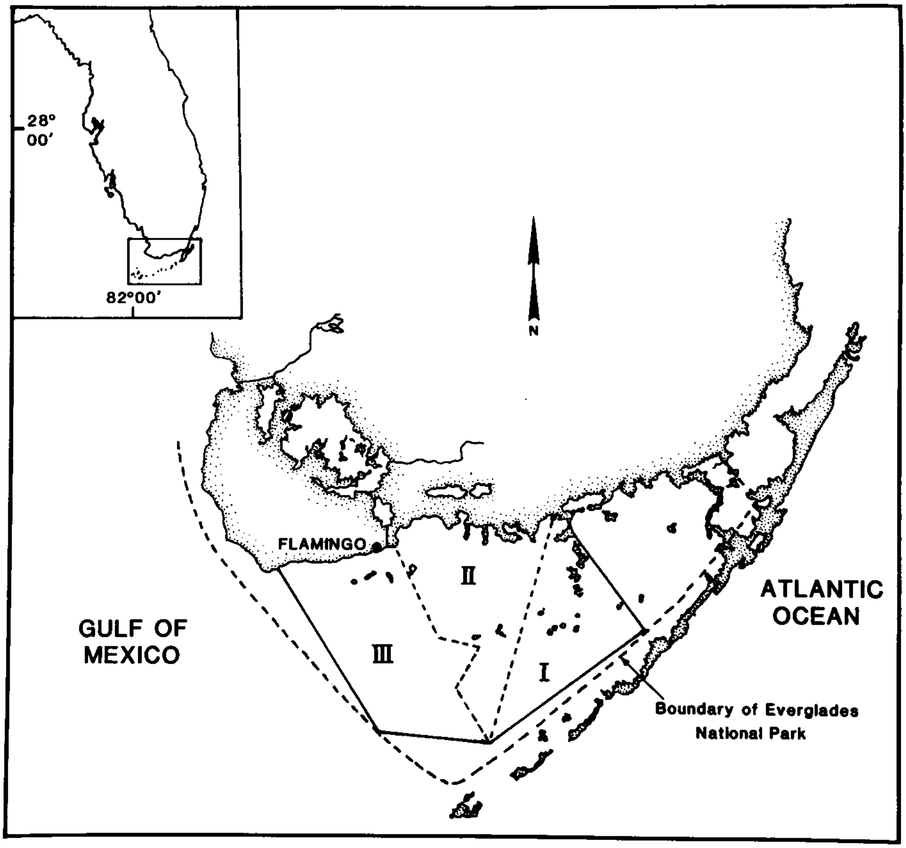

Figure 1. Diagram of Florida Bay showing the location of sampling strata (I, II, III) for nine surveys conducted during 1984 and 1985.

display the greatest abundance, biomass, and numbers of species of juvenile and forage fish (Table 1). The Atlantic Province lies in the southern and eastern portion of the study area (Stratum I and the southern part of Stratum II, Fig. 1). The numerous tidal channels dividing the Florida Keys are major conduits for advective exchange between the basins of this subregion and the Straits of Florida. Sediments are thinner and less organic, mean water depth is greater, the seagrass community is sparse and monospecific (*Thalassia*), and the juvenile and forage fish community is depauperate (Table 1). The Interior Province encompasses the northcentral portion of the Bay (northern part of Stratum II, Fig. 1). Water circulation is restricted and flushing rates are low (Schomer and Drew, 1982). Sediment characteristics are similar to those of the Gulf Province (western Florida Bay), but the seagrass community is less diverse (*Thalassia* dominates), and measures of fish abundance, biomass, and species richness are almost as low as those found to the south and east (Atlantic Province) (Table 1).

Channels are interspersed throughout the Bay, but most lie along the western and southern margins. Water depths are about the same in channels and basins (Table 1). Sediments most resemble those of the Gulf and Interior Provinces, with somewhat lower values for organic matter and sediment thickness and somewhat higher values for silt. Seagrasses in the channels are diverse, with all three species represented. The assemblage resembles that of the Gulf Province, but differs in

Table 1. Comparison of environmental properties of three subregions and channel area of Florida Bay. Data are means from N stations occupied during nine surveys from May 1984 through June 1985. ANOVA results are for comparisons among subregions exclusive of channels. Seagrass and juvenile fish data were transformed logarithmically prior to ANOVA

Parameter	Atlantic (N = 60)	Interior (N = 35)	Gulf (N = 57)	Channels (N = 50)	Sign. of F
Temperature (°C)	27.0	26.6	26.5	26.9	NS
Salinity (‰)	36.8	35.5	35.4	36.2	NS
Organic matter (%)	8.6	16.0	15.5	12.5	**
Silt (%)	45.1	56.3	60.5	64.6	**
Sediment depth (m)	0.6	1.0	1.2	0.9	**
Water depth (m)	1.8	1.1	1.4	1.6	**
Thalassia testudinum					
(shoots·m^{-2})	591	916	586	657	**
(g·m^{-2})	86.8	187.8	168.0	184.8	NS
Halodule wrightii					
(shoots·m^{-2})	6	30	386	988	**
(g·m^{-2})	0.0	0.2	9.6	22.4	**
Syringodium filiforme					
(shoots·m^{-2})	0	0	784	221	**
(g·m^{-2})	0.0	0.0	55.7	19.3	**
Number of fish species	4.5	5.9	10.0	11.0	**
Fish abundance (#·ha^{-1})	432	842	3,304	3,170	**
Fish biomass (kg·ha^{-1})	2.9	3.5	12.6	12.5	**

the tendency for *Halodule* to be more abundant and *Syringodium* less abundant. The demersal fish communities of the channels and Gulf Province are similar in total abundance, biomass, numbers of species (Table 1), and species composition (Thayer and Chester, 1989).

Distribution of Spotted Seatrout and Gray Snapper Juveniles.—A total of 40 spotted seatrout and 99 gray snapper juveniles was collected at the 204 stations occupied during the study. Of these, all but one of each species were captured in the bottom trawl. Absolute population densities are difficult to estimate from individual station data because of unknown net efficiencies which differ with age and size of target species and in different habitats (Kjelson and Johnson, 1978). We have emphasized, therefore, the presence or absence of trout and snapper juveniles, and not relative abundances, in analyzing the distributions of these two species. Although the two species are prized sportfish in Florida Bay as adults, their juveniles are found in low densities regardless of the sampling technique used or its collection efficiency. National Park Service personnel found a total of 125 spotted seatrout and 129 gray snapper juveniles in 377 collections obtained with beach seines and otter trawls during 1973–1976 (Rutherford et al., 1989). From 1982–1984, a total of 147 juvenile seatrout and 18 gray snapper were collected using roller frames, sled nets, seines, hook and line, and explosives (Rutherford et al., 1989). Sogard et al. (1989) collected six gray snapper and one spotted seatrout from 936 throw trap samples and 217 gray snapper and 138 seatrout during 1,498 hours of gillnet sets on carbonate banks in the Bay. Thayer et al. (1987a) collected 27 juvenile gray snapper and two seatrout in eight mangrove prop-root habitats of Everglades National Park.

Spotted seatrout juveniles were most common in basin habitats of the Gulf Province (Stratum III), particularly in the northwestern portion of this area, with

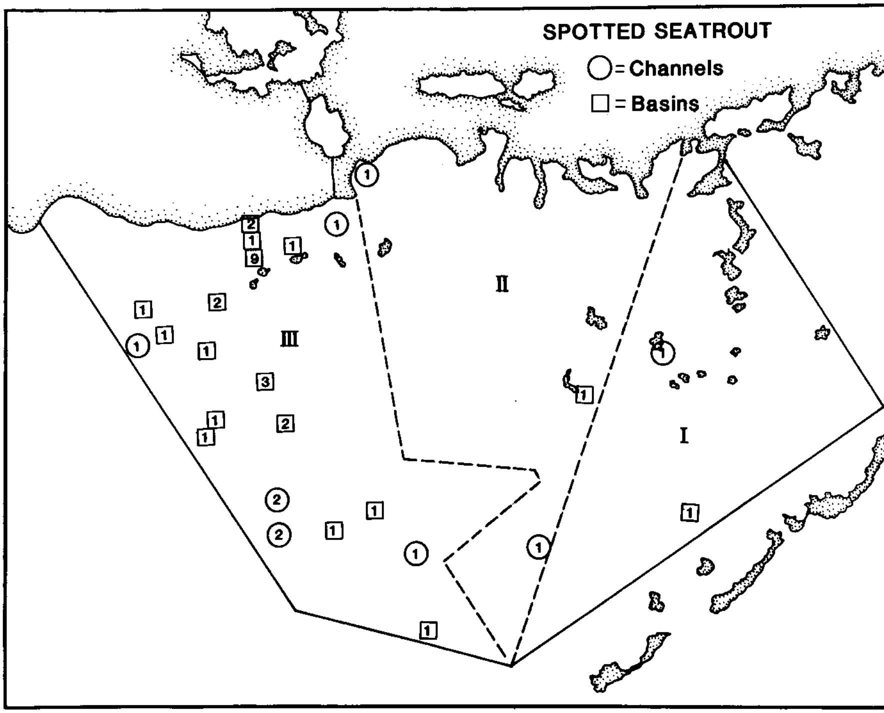

Figure 2. Diagram of Florida Bay showing the location and numbers of spotted seatrout juveniles collected during nine surveys conducted from May 1984 through June 1985.

lesser numbers found in a few scattered channels, mostly in western Florida Bay (Fig. 2). Powell et al. (1989), using data on larval distribution, inferred the greatest spawning activity in this region; Jannke (1971) also noted that spawning occurs in or near passes in the Gulf. Powell et al. (1989) concluded that spawning activity peaks from mid to late spring, moderates during summer, and falls to minimal levels in the fall and winter. Our data support this conclusion. Spotted seatrout juveniles were found during each survey except in May 1984. Smallest individuals were found during May (1985), June (1984, 1985), and July (1984), particularly in the basins (mean wet weight = 3.6 g; range = 0.1–36 g; N = 19). Largest individuals were found September-March (mean wet weight = 26.4 g; range = 1.0–76 g; N = 10). These data suggest that larval spotted seatrout recruit to basin seagrass beds which are near spawning grounds located in and near western Florida Bay. While juveniles also were collected in channels, mean length and weight there tended to be larger (66 mm vs. 107 mm; 11.5 g vs. 76.5 g), but not significantly so (ANOVA and Wilcoxon rank sum test). The distributions of fish length were nonnormal in both channels and basins ($P < 0.05$; W statistic [Shapiro and Wilk, 1965]), but tailed toward larger fish in the channels (Fig. 3). This may reflect either differential net avoidance in the two habitats or a genuine change in habitat preference with age.

Gray snapper juveniles were most prominent in southeastern channel habitats but also occurred, to a lesser extent, in northwestern basins of the Gulf Province (Fig. 4). Gray snapper are believed to spawn on reefs seaward of the Florida Keys, principally during the summer (Starck and Schroeder, 1971; Powell et al., 1989). Juveniles were captured during every survey, with greatest numbers in September

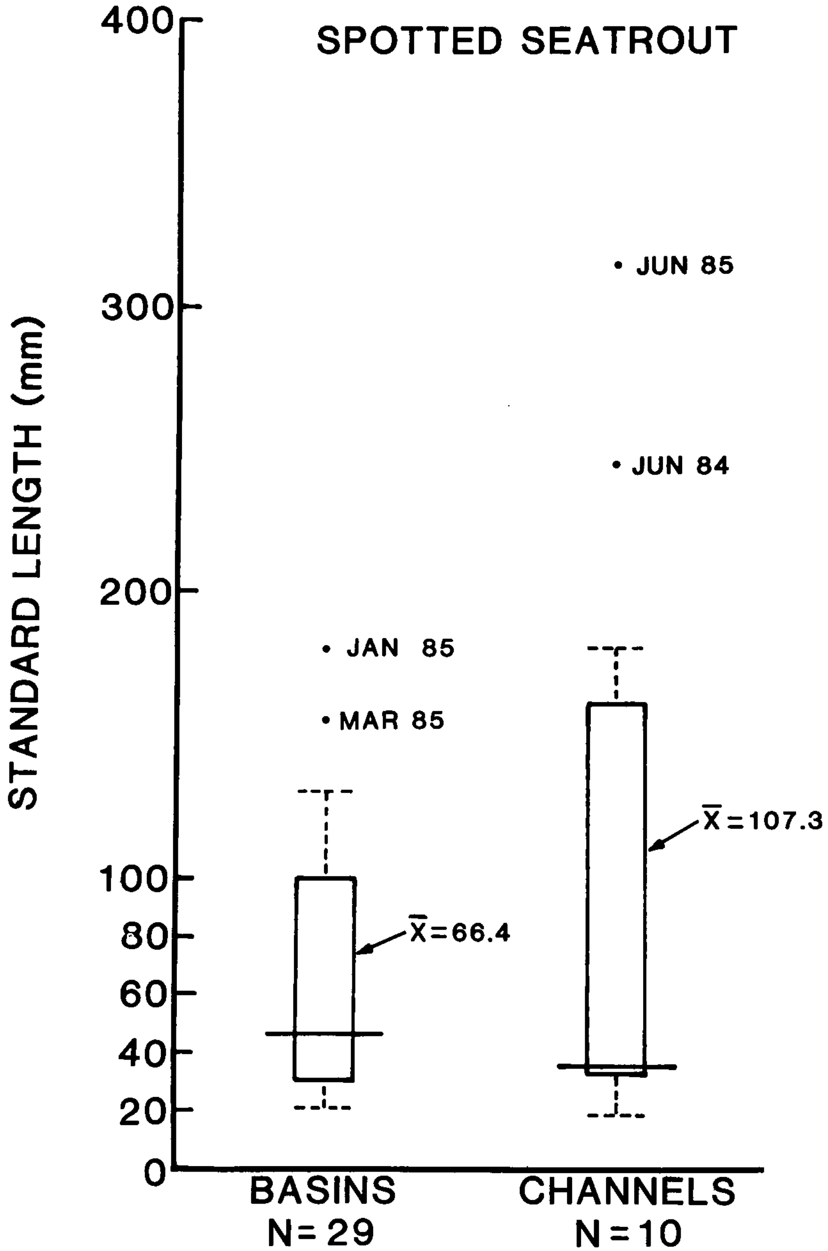

Figure 3. Schematic plots showing the distribution of spotted seatrout standard length in basins and channels of Florida Bay. In each distribution, the rectangle denotes the interquartile range (IQR); the line segment through the rectangle is the median. Dashed lines extend to the last empirical value that is less than the median plus or minus 1.5 (IQR).

1984 (18), March 1985 (19), and May 1985 (23). Smallest individuals occurred January–May (mean wet weight = 17.9 g; range = 0.5–105.0 g; N = 48). Largest individuals occurred June–November (mean wet weight = 63.9 g; range = 0.5–376.0 g; N = 48). Young-of-the-year appear to enter Florida Bay as late-stage

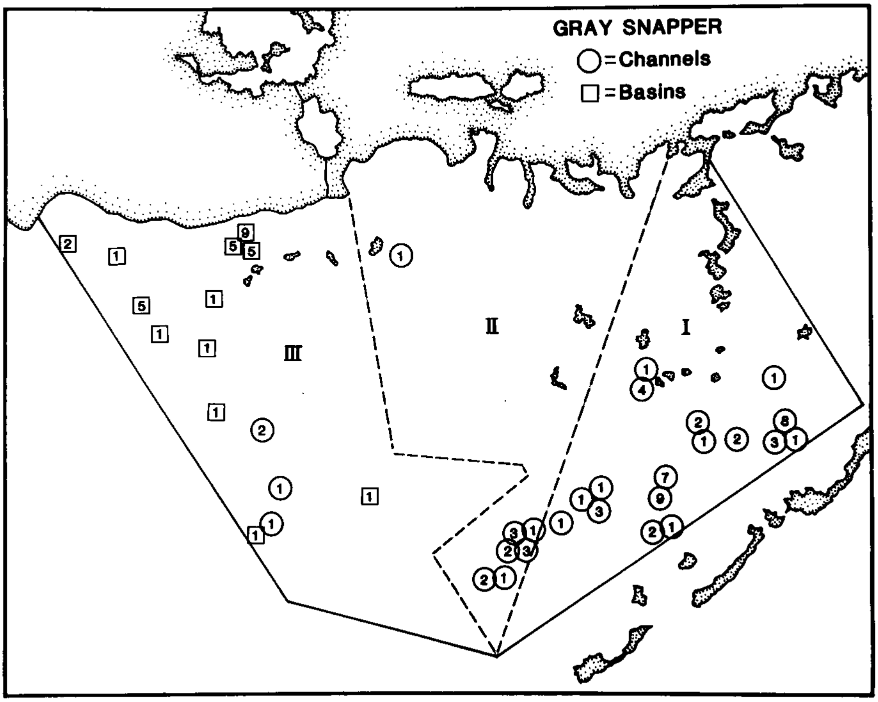

Figure 4. Diagram of Florida Bay showing the location and numbers of gray snapper juveniles collected during nine surveys conducted from May 1984 through June 1985.

Table 2. Product-moment correlation coefficients relating numbers and biomass (log X + 1 transformed) of juvenile spotted seatrout and gray snapper with environmental parameters measured in Florida Bay, 1984–1985. Only coefficients significant at $P < 0.05$ are reported

	N	Spotted seatrout		Gray snapper	
		Numbers	Biomass	Numbers	Biomass
Temperature (°C)	204				
Salinity (‰)	204				
Organic matter (%)	204	0.28	0.25		
Silt (%)	149	0.17	0.17	0.17	0.18
Sediment thickness (m)	204	0.16	0.20		
Water depth (m)	204				
Thalassia testudinum					
(shoots·m^{-2})	202				
(g·m^{-2})	202				
Halodule wrightii					
(shoots·m^{-2})	202		0.21	0.26	0.24
(g·m^{-2})	202		0.22	0.27	0.26
Syringodium filiforme					
(shoots·m^{-2})	202	0.35	0.16	0.27	0.30
(g·m^{-2})	202	0.35	0.15	0.28	0.31
Juvenile Fish Community					
(numbers)	204	0.34	0.21	0.46	0.47
(biomass)	204	0.32	0.25	0.50	0.52
(numbers of species)	204	0.43	0.30	0.58	0.57

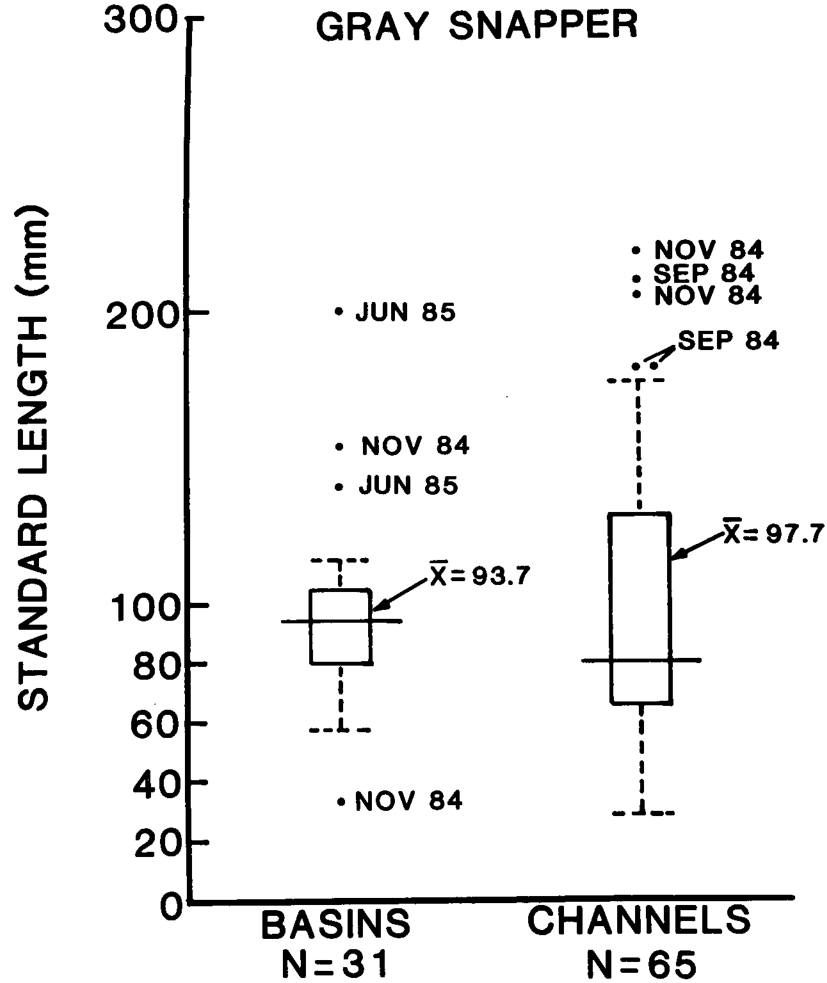

Figure 5. Schematic plots showing the distribution of gray snapper standard length in basins and channels of Florida Bay. In each distribution, the rectangle denotes the interquartile range (IQR); the line segment through the rectangle is the median. Dashed lines extend to the last empirical value that is less than the median plus or minus 1.5 (IQR).

larvae and then recruit to channels, where seagrass communities are more diverse and luxuriant than in surrounding basins of the Atlantic subregion (Table 1). It is not clear whether the presence of juveniles in northwest basins signifies population movements within the Bay, or reflects spawning activity in the Gulf of Mexico. Mean lengths and weights of snapper juveniles did not differ significantly between channel and basin habitats (98 mm vs. 94 mm; 46 g vs. 30 g). Length frequency distributions were nonnormal in both areas ($P < 0.05$; W statistic), but data from the channels appear more skewed, tailing toward somewhat larger fish (Fig. 5).

Juvenile Distributions and Environmental Parameters.—Gray snapper and spotted seatrout juveniles occurred most often where seagrass density and species diversity were high. For gray snapper, 80% were captured in or near beds exceeding 1,000

Table 3. A. Means and significance levels (ANOVA and MANOVA) for variables used to distinguish stations with from stations without spotted seatrout juveniles. Significance levels (denoted by * at $P < 0.05$) are for log (X+1) transformations of seagrass data; B. Variables included in the discriminant functions with standardized discriminant coefficients; C. Classification results

A. Variable	Basin stations (strata 1–3)			Channel stations (stratum 4)		
	Trout (N = 16)	No trout (N = 136)	Sign.	Trout (N = 7)	No trout (N = 43)	Sign.
Temperature (°C)	27.1	26.7	0.68	28.0	26.8	0.41
Salinity (‰)	35.3	36.0	0.54	36.1	36.2	0.96
Organic matter (%)	19.1	12.2	0.00*	14.9	12.1	0.22
Sediment thickness (m)	1.3	0.9	0.00*	1.1	0.9	0.16
Water depth (m)	1.5	1.5	0.85	1.4	1.6	0.45
Thalassia						
(shoots·m^{-2})	619	664	0.44	629	647	0.74
(g·m^{-2})	191.4	133.6	0.48	246.9	170.7	0.52
Halodule						
(shoots·m^{-2})	148	153	0.44	662	1,018	0.26
(g·m^{-2})	3.5	3.6	0.29	25.4	21.5	0.31
Syringodium						
(shoots·m^{-2})	1,067	202	0.00*	443	181	0.14
(g·m^{-2})	68.8	15.1	0.00*	35.5	16.3	0.12
MANOVA:			0.00*			0.07

B. Discriminant function	Basin stations		
	Standardized coefficient	Correlation coefficient	Channel stations
Temperature	0.21	0.06	non-significant
Organic matter	0.60	0.61	
Sediment thickness	0.31	0.42	
Water depth	0.48	−0.03	
Syringodium			
(numbers)	2.46	0.75	
(biomass)	−1.84	0.73	

C. Classification

Actual group	Basin stations predicted group membership		
	N	Trout	No trout
Trout	16	11 (69%)	5 (31%)
No trout	136	22 (16%)	114 (84%)

shoots·m^{-2}; 63% were found at stations having at least two species of seagrass. For spotted seatrout, 65% were captured where seagrass densities exceeded 1,000 shoots·m^{-2}; 84% occurred with at least two seagrass species. The primary difference was the preference for basin areas by spotted seatrout and channels by gray snapper.

Correlation coefficients between environmental parameters and numbers and biomass of spotted seatrout and gray snapper juveniles indicated weak, but statistically significant, linear associations (Table 2) among paired variables. The strongest relationships linked snapper and trout abundance and biomass with the abundance, biomass, and number of species comprising the entire juvenile fish community. Weaker relationships existed with percent organic matter and silt in the sediments, and with numbers and biomass of the seagrass species, *Halodule wrightii* and *Syringodium filiforme*.

Table 4. A. Means and significance levels (ANOVA and MANOVA) for variables used to distinguish stations with from stations without gray snapper juveniles. Significance levels (denoted by * at $P < 0.05$) are for log (X+1) transformations of seagrass data; B. Variables included in the discriminant functions with standardized discriminant coefficients; C. Classification results

A. Variable	Basin stations (strata 1–3)			Channel stations (stratum 4)		
	Snapper (N = 12)	No snapper (N = 140)	Sign.	Snapper (N = 28)	No snapper (N = 22)	Sign.
Temperature (°C)	26.2	26.8	0.59	27.5	26.2	0.24
Salinity (‰)	35.9	36.0	0.97	35.3	37.4	0.08
Organic matter (%)	19.0	12.4	0.00*	12.0	13.1	0.48
Sediment thickness (m)	1.1	0.9	0.12	0.8	1.0	0.08
Water depth (m)	1.3	1.5	0.12	1.8	1.2	0.00*
Thalassia						
(shoots·m^{-2})	453	677	0.01*	808	428	0.02*
(g·m^{-2})	103.6	142.7	0.19	226.4	121.5	0.01*
Halodule						
(shoots·m^{-2})	119	156	0.70	1,212	649	0.26
(g·m^{-2})	2.4	3.7	0.67	25.9	16.9	0.32
Syringodium						
(shoots·m^{-2})	1,614	180	0.00*	316	86	0.24
(g·m^{-2})	118.5	12.4	0.00*	28.1	6.8	0.21
MANOVA:			0.00*			0.00*

B. Discriminant function	Basin stations		Channel stations	
	Standardized coefficient	Correlation coefficient	Standardized coefficient	Correlation coefficient
Temperature			0.27	0.20
Salinity			−0.39	−0.31
Organic matter	0.43	0.39	−0.32	−0.12
Sediment thickness	−0.31	0.17		
Water depth	−0.33	−0.17	0.77	0.62
Thalassia (biomass)	−0.36	0.03	0.71	0.44
Halodule (numbers)	−0.22	0.04		
Syringodium (biomass)	0.93	0.85		

C. Classification

	Basin stations predicted group membership			Channel stations predicted group membership		
Actual group	N	Snapper	No snapper	N	Snapper	No snapper
Snapper	12	10 (83%)	2 (17%)	28	23 (82%)	5 (18%)
No snapper	140	11 (8%)	129 (92%)	22	3 (14%)	19 (86%)

Stations in basin habitats at which spotted seatrout were collected had significantly deeper, more organic sediments and greater numbers and biomass of *Syringodium filiforme* than did stations without seatrout (ANOVA, $P < 0.05$). No similar differences were detected for channel stations (Table 3). The discriminant function derived for basin stations indicated that high sediment organic matter and dense stands of *Syringodium* were diagnostic of spotted seatrout habitat (Table 3). A relatively accurate separation of trout and nontrout stations was effected, with 82% of the 152 basin stations correctly classified (Table 3). Discriminant analysis was not conducted for channel stations, because the MANOVA was not significant.

Stations in basin habitats at which gray snapper were caught had organically richer sediments, greater shoot densities of *Thalassia,* and greater shoot densities and biomass of *Syringodium* than did stations without gray snapper. In the channels, water depth was greater and *Thalassia* populations better developed at stations with gray snapper (Table 4). The discriminant function for basins indicated the importance of *Syringodium* in defining gray snapper habitat; the analysis successfully classified 91% of the 152 basin stations. The discriminant function for channels identified water depth and *Thalassia* biomass as the most influential variables; 84% of the 50 channel stations were correctly classified (Table 4).

Seagrass meadows are critical habitats for the young of fishery organisms because they simultaneously afford abundant food resources and refuge from predators (see reviews by Thayer et al., 1984; Gilmore, 1987; Kenworthy et al., 1988). Both of these nursery functions (i.e., food and shelter) have been linked to seagrass habitat "complexity." Complexity was generally equated with total seagrass biomass or plant surface area in earlier studies (Heck and Wetstone, 1977; Stoner, 1980), but this concept has been expanded to include species composition (Stoner, 1983; Virnstein, 1987; Virnstein and Howard, 1987; Thayer and Chester, 1989) and spatial patchiness (Holt et al., 1983; Orth et al., 1984), factors which help define the degree of habitat heterogeneity.

In Florida Bay, the abundance and distribution of young spotted seatrout and gray snapper, as well as juveniles and small-sized adults of other fish species (Thayer and Chester, 1989), appear to be influenced by the biomass, shoot density, and species composition of the seagrass community. Little is known about the predation mortality of these gamefishes or the relative protection provided by different densities and species of seagrass, but it is quite likely that large piscivores are less efficient predators in seagrass beds than they are over unvegetated or sparsely vegetated bottoms. Seagrass blades not only interfere with the movement and foraging efficiency of larger predators, but the canopy itself reduces light, thereby reducing visibility of predators, and provides camouflage for prey (Kenworthy et al., 1988). Stoner (1983) speculated that the long, wide shoots of *Thalassia* may provide better protection from predators than the relatively thin shoots of *Syringodium,* but he also identified *Halodule,* despite its low biomass, as good refuge cover for juvenile fish because of its generally high shoot density.

Seagrass density and species composition also affect the densities and kinds of prey items and their susceptibility to juvenile fish. In Indian River Lagoon, Florida, for example, Virnstein and Howard (1987) found that, while the suite of epifaunal species did not differ markedly by seagrass species, the relative abundance did. *Halodule* had the greatest gastropod densities and *Thalassia* had the greatest crustacean densities per unit of bottom area. However, when densities were normalized by plant biomass or surface area, crustaceans were far more abundant on *Syringodium.* Livingston (1982) pointed out that the smallest size classes of many species of fish first feed heavily on amphipods, and then, as these fish grow, they shift to larger prey. In Florida Bay, postlarval pink shrimp are most abundant in *Halodule* beds, and early juveniles are highly associated with this seagrass species (Costello and Allen, 1969; Costello et al., 1986). Hettler (1989) found that spotted seatrout less than 30 mm collected from Florida Bay seagrass meadows fed on amphipods, mysids, and caridean shrimp, while fish greater than 30 mm fed heavily on pink shrimp. Gray snapper less than 30 mm ate crab zoea/megalopa and caridean shrimp while in channels, but those collected from grass beds fed on pink shrimp, caridean shrimp, and small fishes. Larger gray snapper collected from channels fed heavily on fish and caridean shrimp, while those from grass beds fed predominantly on pink shrimp.

The observed relationships between environmental factors and the distributions of juvenile trout and snapper remain to be verified by a more experimental approach. There are strong indications, however, that seagrass species composition and abundance constitute major structural and functional components of gamefish and non-gamefish habitat in Florida Bay. In particular, we believe that seagrass meadows with mixtures of *Thalassia* and either *Syringodium* or *Halodule* are critical habitats for spotted seatrout and gray snapper. Differences in the morphology and the relative abundance and availability of prey organisms on and among seagrass shoots of different species enhance habitat heterogeneity and present ichthyofauna with a rich array of sub-environments, each offering a different balance between feeding opportunity on one hand and protection from predators on the other.

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Literature Cited

Costello, T. J. and D. M. Allen. 1969. Ecology of pink shrimp in Florida Bay. U.S. Fish Wildl. Serv. Circ. 325: 9–10.

———, D. M. Allen and J. H. Hudson. 1986. Distribution, seasonal abundance, and ecology of juvenile northern pink shrimp, *Penaeus duorarum,* in the Florida Bay area. NOAA Tech. Memo. NMFS-SEFC-161. 84 pp.

Gilmore, R. G. 1987. Subtropical-tropical seagrass communities of the southeastern United States: fishes and fish communities. Fla. Mar. Res. Publ. 42: 117–137.

Heck, K. L. and G. S. Wetstone. 1977. Habitat complexity and invertebrate species richness and abundance in tropical seagrass meadows. J. Biogeogr. 4: 135–142.

Hettler, W. F. 1989. Food habits of juveniles of spotted seatrout and gray snapper in western Florida Bay. Bull. Mar. Sci. 44: 155–162.

Holt, S. A., C. L. Kitting and C. R. Arnold. 1983. Distribution of young red drums among different sea-grass meadows. Trans. Am. Fish. Soc. 112: 267–271.

Jannke, T. E. 1971. Abundance of young sciaenid fishes in Everglades National Park, Florida in relation to season and other variables. Univ. Miami Sea Grant Tech. Bull. 11. 128 pp.

Johnson, D. R. and W. Seaman. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (south Florida)—spotted seatrout. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.43). 18 pp.

Kenworthy, W. J., G. W. Thayer and M. S. Fonseca. 1988. The utilization of seagrass meadows by fishery organisms. Pages 548–560 *in* D. D. Hook, W. H. McKee, Jr., H. K. Smith, J. Gregory, V. G. Burrell, Jr., M. R. Devoe, R. E. Sojka, S. Gilbert, R. Banks, L. H. Stolzy, C. Brooks, T. D. Matthews and T. H. Shear, eds. The ecology and management of wetlands, Vol. 1. Timber Press, Portland, Oregon.

Kjelson, M. A. and G. N. Johnson. 1978. Catch efficiencies of a 6.1-meter otter trawl for estuarine fish populations. Trans. Am. Fish. Soc. 107: 246–254.

Livingston, R. J. 1982. Trophic organization of fishes in a coastal seagrass system. Mar. Ecol. Prog. Ser. 7: 1–12.

Orth, R. J., K. L. Heck and J. van Montfrans. 1984. Faunal communities in seagrass beds: a review of the influence of plant structure and prey characteristics on predator-prey relationships. Estuaries 7: 339–350.

Powell, A. B., D. E. Hoss, W. F. Hettler, D. S. Peters and S. Wagner. 1989. Abundance and distribution of ichthyoplankton in Florida Bay and adjacent waters. Bull. Mar. Sci. 44: 35–48.

Rutherford, E. S., T. W. Schmidt and J. T. Tilmant. 1989. Early life history of spotted seatrout (*Cynoscion nebulosus*) and gray snapper (*Lutjanus griseus*) in Florida Bay, Everglades National Park, Florida. Bull. Mar. Sci. 44: 49–64.

Schomer, N. S. and R. D. Drew. 1982. An ecological characterization of the lower Everglades, Florida Bay and the Florida Keys. U.S. Fish Wildl. Serv. Biol. Serv. Prog. FWS/OBS-82/58.1. 246 pp.

Shapiro, S. S. and M. B. Wilk. 1965. An analysis of variance test for normality (complete samples). Biometrika 52: 591–611.

Snapinn, S. M. and J. D. Knoke. 1984. Classification error rate estimators evaluated by unconditional mean squared error. Technometrics 26: 371–378.

Sogard, S. M., G. V. N. Powell and J. G. Holmquist. 1989. Spatial distribution and trends in abundance of fishes residing in seagrass meadows on Florida Bay mudbanks. Bull. Mar. Sci. 44: 179–199.

Starck, W. A. and R. E. Schroeder. 1971. Investigations of the gray snapper, *Lutjanus griseus*. Stud. Trop. Oceanogr. (Miami) 10. 224 pp.

Stoner, A. W. 1980. The role of seagrass biomass in the organization of benthic macrofaunal assemblages. Bull. Mar. Sci. 30: 537–551.

———. 1983. Distribution of fishes in seagrass meadows: role of macrophyte biomass and species composition. U.S. Fish. Bull. 81: 837–846.

Thayer, G. W. and A. J. Chester. 1989. Distribution and abundance of fishes among basin and channel habitats in Florida Bay. Bull. Mar. Sci. 44: 200–219.

———, D. R. Colby and W. F. Hettler. 1987a. Utilization of the red mangrove prop root habitat by fishes in south Florida. Mar. Ecol. Prog. Ser. 35: 25–38.

———, W. J. Kenworthy and M. S. Fonseca. 1984. The ecology of eelgrass meadows of the Atlantic coast: a community profile. U.S. Fish Wildl. Serv. FWS/OBS-84/02. 147 pp.

———, W. F. Hettler, A. J. Chester, D. R. Colby and P. J. McElhaney. 1987b. Distribution and abundance of fish communities among selected estuarine and marine habitats in Everglades National Park. U.S. Natl. Park Serv., S. Fla. Res. Cent. Tech. Rep. SFRC-87/02. 166 pp.

Tilmant, J. T., E. S. Rutherford, R. H. Dawson and E. B. Thue. In press. Impacts of gamefish harvest in Everglades National Park *in* R. Hermann and T. Bostedt-Craig, eds. Proceedings of the conference on science in the national parks. George Wright Society and National Park Service, Washington, D.C.

Virnstein, R. W. 1987. Seagrass-associated invertebrate communities of the southeastern U.S.A.: a review. Fla. Mar. Res. Publ. 42: 89–116.

——— and R. K. Howard. 1987. Motile epifauna of marine macrophytes in the Indian River Lagoon, Florida. I. Comparisons among three species of seagrasses from adjacent beds. Bull. Mar. Sci. 41: 1–12.

Zieman, J. C. 1982. The ecology of the seagrasses of south Florida: a community profile. U.S. Fish Wildl. Serv., Biol. Serv. Prog. FWS/OBS-82/25. 124 pp.

———, J. W. Fourqurean and R. L. Iverson. 1989. Distribution, abundance and productivity of seagrasses and macroalgae in Florida Bay. Bull. Mar. Sci. 44: 292–311.

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